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BRIQUETTING OF INDIAN LIGNITES

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BRIQUETTING OF INDIAN LIGNITES

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1. INTRODUCTION

1.1. In India lignites occur in South Arcot (Neyveli) and several other coastal regions of the southern peninsula (Travancore and Malabar), in Rajasthan (Palana), Kutch (Umarsar) and in certain parts of Kashmir. Almost all these regions do not have any known deposits of bituminous coal (there is some coal in Kashmir) and assuring supplies of energy and power in these areas for industrial and domestic uses has long been a problem. In recent years the exploitation of Indian lignites has been given the importance that it deserves and elaborate plans have been prepared for the working and efficient utilisation of the lignite deposits of South Arcot. Prior to this, lignite has been commercially mined to a limited extent in Bikaner, mainly to provide fuel for thermal power stations.

1.2. The development of the lignite of South Arcot will provide a source of fuel not only for the industries of Madras and the South in general but also for thermal stations for providing power for industries, electrification of railways, etc. This will accelerate the industrialisation of southern India. At present, hydro-electric generators are the main source of power supply in Madras State but during periods of draught there have often been drastic cuts in power supply resulting in loss of lakhs of rupees annually incurred by the industries. Cheap thermal power by utilising locally occurring lignite will form an important addition to the existing power supply system. Further, a portion of the wagons now required for coal transportation from the coalfields of the Northern India and from ports, will be released for other transport and the ports themselves will be relieved of pressure and will be able to handle more goods - both exports and imports.

1.3. The potential uses of lignite are many and varied. Lignites are, however, liable to weathering, crumbling and disintegration. In unprocessed form they can be used in boilers located near the mines, which may not always be possible because there may not be sufficient local demand for power.

1.4. Lignites have high moisture (50-60 per cent) and low calorific value (average 5,500 B.t.u./lb) and if it has to compete with bituminous coal it has to be processed and upgraded. The upgrading can be done by drying and briquetting, when it is converted into sizes and shapes suitable for handling and for withstanding transportation. At the same time the heat value is increased per unit weight.

1.5. The removal of moisture is an essential pre-requisites for the upgrading of lignite and for its industrial utilisation. The drying of lignite, however, leads to loss of coherence, and it disintegrates into powdery form on handling and transport. Briquetting of the dry lignite produces coherent shapes. Also, where long distance transport is involved, briquetted lignite can be transported at a lesser cost than high moisture raw lignite. Briqutted and carbonised lignite would be more readily acceptable as a domestic fuel because of the less smoke it produces than raw lignite. As an industrial fuel, lignite briquettes can be easily burnt in "step-grate" or "trough-grate" or even "Horizontal grate" type of boilers. They can also be burnt in normal handfired or chain-grate boilers, with certain modifications to the plant. Briquetting of lignite is achieved under pressure (10-12 tons p.s.i) and at a critical moisture, which, in the case of Indian lignites vary between 13 and 16 per cent.

1.6. Briquetting of lignite or brown coal has been operated on a large scale in Germany and other European countries as well as in Australia. In Germany and in Australia no binder is used for briquetting of lignites. Although the process of briquetting is a simple one, fairly elaborate and expensive plant is required for quantity production necessary to achieve economical costs. The successive stages are : crushing, screening, drying, cooling, pressing, dust control, steam boiler, power generation, conveying and loading.

2. WORK DONE AT CENTRAL FUEL RESEARCH INSTITUTE, INDIA

2.1. At the Central Fuel Research Institute in India investigations have been undertaken into the properties and uses of lignite, particularly from South Arcot[1-8]. Besides the usual physical and chemical analyses, much work has been done on lignite drying and briquetting, the behaviour on low temperature carbonisation, the chemical composition of the low temperature tar, the oxidation and hydrogenation of the lignite, etc. Plans for utilisation in industries have also been prepared. In the present paper will be discussed only the briquetting of lignites.

2.2. The lignites from South Arcot, Palana, and Kutch usually have between 20 to 30 per cent moisture and 6 to 16 per cent ash on air-dried basis, but the Kashmir lignites are characterised by lower moisture of about 10-12 per cent and higher ash of about 45-50 per cent on air-dried basis. (a) South Arcot Lignite: (i) The critical moisture content for briquetting remains constant (about 16.8 per cent) upto a briquetting pressure of 10 tons/sq.in. At higher pressures of the order of 16-17 tons/sq.in., the optimum moisture content decreases to 12 per cent.

(ii) The specific gravity of the briquette is maximum at the critical moisture percentage. The briquettes retain their shape during combustion. The briquettes, however, disintegrate on immersion in water. (b) Palana Lignites: (i) Palana lignites are similar in briquetting properties to South Arcot lignites in spite of slightly higher rank and ash content. The optimum moisture content is about 16-17 per cent at pressures below 10 tons/sq.in. and 12 per cent at pressures of 16-17 tons/sq. in. These briquettes burn easily retaining their shape during combustion. These briquettes also disintegrate on immersion in water. (c) Kutch Lignites: (i) These are lower in rank than the South Arcot lignite and also have somewhat higher percentage of ash (about 16 per cent on air-dried basis). The briquetting properties of Kutch lignite

are however inferior to those of South Arcot and in order to get fairly strong briquettes it would be necessary to crush the lignite to finer sizes (-72 mesh B.S.S.) before briquetting. The carbonized briquettes are somewhat stronger than the uncarbonised briquettes.

(d) Kashmir Lignites: (i) The apparent specific gravity of the briquettes was 1.4-1.5 which is high compared to the corresponding figure of 1.2 for South Arcot lignites. This might be due to the considerably higher ash content of the lignite. But in spite of the very high ash content, the briquetting properties of Kashmir lignites are similar to those of Palana and South Arcot lignites. The optimum moisture, in this case also, is 16-17 per cent at pressures below 10 tons/sq.in. but decreases to about 12 per cent at higher pressures. The strength of the briquettes is only lower than that obtained with Palana and South Arcot lignites, and like the latter they disintegrate on immersion in water. The briquettes burn with difficulty due to their high ash content and special type of combustors have to be designed for their efficient burning.

(ii) Experiments carried out on the low pressure briquetting of Kashmir lignite treated with lime water showed that these briquettes were stronger than those obtained with pitch as a binder and also have fairly good burning characteristics[9]. An explanation for the role of lime water may be found in the fact that being an electrolyte it perhaps causes the flocculation of the colloidal clay associated with the lignite and that these act as binder. Based on these investigations a full scale (10 tons/hour) plant is being installed at Srinagar for briquetting Kashmir lignite.

(iii) The effect of briquetting pressure, moisture and the presence of saw dust on the burning characteristics of Kashmir lignite briquettes were studied in a specially designed thermogravimetric balance. The results showed that the briquettes burn rapidly but that the rate can be lowered by increasing the briquetting pressure; increased moisture content raises the combustion rate. There is also a tendency for the saw dust to burn preferentially but this can be overcome by hot briquetting at 180-200°C at a pressure of 8,000 lb./sq.in.

3. CARBONIZATION OF LIGNITE BRIQUETTES[10,11]

3.1. Lignite briquettes when carbonized under normal conditions yield a powdery char. Under controlled conditions, however, particularly by regulating the rate of heating, it is possible to obtain strong briquettes.

3.2. In the laboratory experiments carried out at the Central Fuel Research Institute, briquettes were prepared at 23.67 tons/sq.in. pressure using Palana and South Arcot lignites crushed to -72 mesh B.S.S. and dried to different moisture contents. These briquettes were carbonised in a stream of nitrogen in an electrically heated furnace at different rates of heating. It was noted that (1) maximum mechanical strength was obtained by carbonising briquettes with 5-6 per cent moisture; (2) even under optimum conditions, the strength of briquettes on carbonisation was generally lower than that of raw briquettes; (3) the rate of carbonization had a great effect on the mechanical strength of the briquettes, carbonisation at 5°C/min. and below gave good briquettes; above this rate, the briquettes obtained were generally poor; (4) about 15-20% breakage occurred on carbonisation at 850°C under optimum conditions (moisture 5 per cent, rate of hea-

ting, 2°C/min.). The compression strength of the carbonised briquettes varied from 3500 to 6000 lb./sq.in.

3.3. An interesting correlation has been noted between temperature of carbonization and compression strength. The briquettes were heated at 2°C/min. in a stream of nitrogen, to the desired temperature, cooled and their compression strength determined. The strength decreased to a minimum at about 450°C and then increased with rise in temperature. From the tests carried out upto 850°C it appeared that the strength would continue to increase with further increase in carbonization temperatures.

4. ROLE OF MOISTURE AND OF RELATIVE HUMIDITY

4.1. The strength of the briquettes is significantly influenced by changes in the moisture content rather than changes in the mineral matter of the lignites[7]. The strength might be attributed to either the presence of forces of cohesion between its component particles or to the forces of adhesion between water and the surface of the component particles. The former forces are due to the interplay of the 'secondary' or 'surfaces' forces which are set up as a result of certain intramolecular rearrangements. The binding due to these forces has been also called 'true cohesion'.

4.2. If the forces of cohesion are operating in the briquette, the determining factor in the strength of the briquette would be the elastic constant of coal. This is known to change with the mineral matter content of coal. Since the lignites contain widely varying proportions of mineral matter, their elastic constants should also be different and, therefore, their briquetting properties should have been different. But the fact that the lignites exhibit similar briquetting properties, in that their strength is significantly influenced by the variation in moisture, would indicate that the strength of the briquette is largely due to the forces of adhesion. The determining factor in this case is then the adhesion energies. The adhesion energies are known to change with moisture content.

4.3. The relative humidity of the atmosphere has considerable influence on the strength of lignite briquettes[8]. Briquettes prepared at 11-17 tons/sq.in. pressure with 12.4 per cent moisture are relatively less liable to changes in relative humidity and have compression strength of 3500-4500 lb./sq.in. under adverse humidity conditions.

4.4. The weakening of the briquettes on exposure to high R.H. can be explained in terms of van der Waal forces which become dominant when the optimum moisture content in the briquette is exceeded.

5. MECHANISM OF BRIQUETTING

5.1. Investigations on the mechanism of briquetting involved in lignite were also undertaken[12]. The reactive groups present in lignite were estimated after the groups were blocked by acetylation and by barium acetate treatment. On briquetting the strength of the lignite briquettes was reduced considerably. Also, briquetting with polar and non-polar liquids showed that the strength of the lignite briquettes increased with increase in the hydrogen bonding capacity of the binder. Other evidences like the behaviour of lignite briquettes on immersion in water, the thermodynamic aspects of sorption of moisture on lignite, the physico-chemical behaviour of lignite during compression, etc.,

coupled with the above results indicate that hydrogen bonding involving both the OH and COOH groups and the "optimum moisture" are mainly responsible for imparting strength to lignite briquettes[13].

6. FERROCOKE FROM LIGNITE & MAGNETITE ORES

6.1. Studies have been carried out on the manufacture of ferrocoke from South Arcot lignite and Salem magnetite ore with a view to using it in iron and steel industry[14]. It has been found that straight blends of lignite-magnetite containing upto 15 per cent iron ore yield ferrocoke briquettes of compressive strength 1000 lb/sq.in. and 64 per cent of the ore in the briquette is reduced to metallic iron. The iron ore concentration can be doubled by mixing 10 per cent of high or low volatile coking coals without weakening the ferrocoke briquettes. The ferrocoke obtained with lignite-slaked lime-iron ore in the ratio 70:15:15 is similar in strength to that obtained with lignite-iron ore in the ratio 85:15. Increase in the concentration of slaked lime to 30 per cent adversely affects the strength of the ferrocoke.

7. INTEGRATED DEVELOPMENT OF SOUTH ARCOT LIGNITE

7.1. Based on the investigations carried out at Central Fuel Research Institute[1] and on some tests conducted in West Germany, elaborate and ambitious plans for the mining and efficient utilisation of South Arcot lignite have been prepared by the Government of India. An autonomous body, Neyveli Lignite Corporation, has been set up and the initial plans are to mine 3½ million tons of lignite per year, the method of winning being that followed in west Germany and in Australia. Of the 3½ million tons to be mined about 1½ million tons per year will be used for the generation of power in a thermal station of 250,000 kW capacity. This will be made available to the Madras Grid to supplement the power generated in the existing hydel power stations which have rather wide seasonal fluctuations as far as the load capacity is concerned. Plans have also been prepared for the establishment of a fertilizer plant to produce 152,000 tons of urea per year using about ½ million tons of lignite as the raw material. This urea plant will be among the largest in the world. The balance of the 1½ million tons of lignite per year that will be raised will be briquetted and carbonised with a view to providing smokeless fuels which will be eminently suitable for domestic consumption in place of charcoal and also for general industrial uses. Initially, about 380,000 tons of carbonised briquettes will be produced, when 43,000 tons of char dust, 6400 tons of motor spirit, 51,300 tons of tar and 1032 tons of phenol will also be obtained as by-products. The char dust can be used in the calcium carbide industry and also for the manufacture of activated carbon, carbon electrodes, etc., while the phenols would find ready use in the plastics and coal chemicals industry. During the mining operations for the removal of over-burden, excellent quality of china clay will be available. This will be washed and used for the manufacture of ceramics. The integrated lignite project of South Arcot will thus help towards relieving the acute shortage of electric power in the Madras region both for domestic and industrial uses, will provide fuel for the common man and for industry and also fertilizers for the improvement of agricultural production. Successful implementation of the project will, no doubt, help the progress of industrialization in Southern India.

7.2. Looking to the future, there is a possibility of South Arcot Lignite being used for the production of coke suitable for reduction

of iron ore in low shaft furnaces. The byproducts that will be obtained from carbonisation of the lignite can serve as starting material for the production of many chemicals and industrial intermediates. A good amount of work has also been done on the carbonisation characteristics of these lignites at the Central Fuel Research Institute. There is also a possibility of gasifying the lignite and using the gas so produced for the synthesis of liquid fuels. Useful products like Montan Wax can also be extracted from the lignite.

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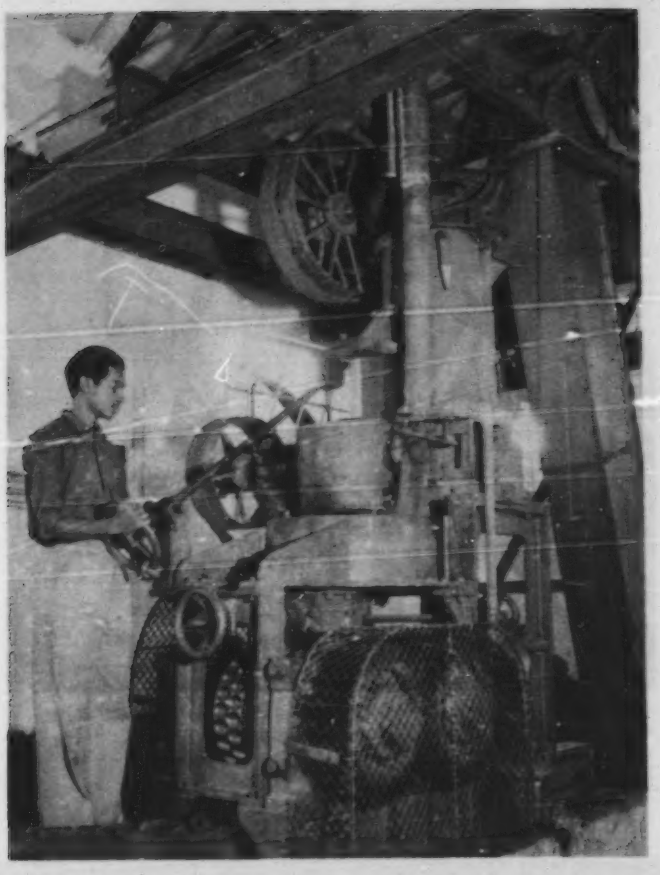

Fig. 1 - A view of the 1½ tons per hour Briquetting Plant at Central Fuel Research Institute.

Fig. 2 - Briquettes

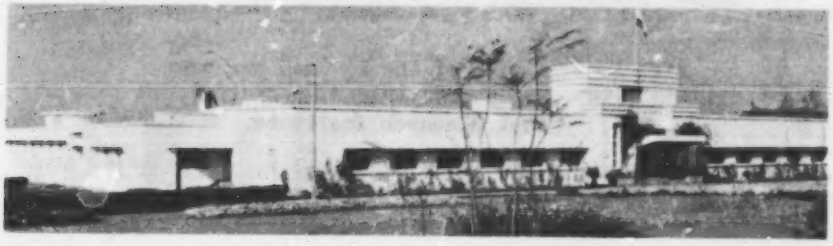

Fig. 3 - A view of the Front Building of the Central Fuel Research Institute

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